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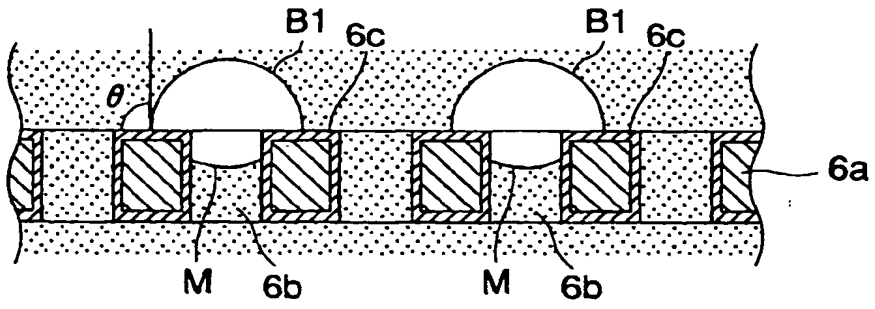
(54) Ink-jet recording device

(57) An ink lyophilic layer 6c is formed on the upstream face of a filter member 6, so that an air bubble B1 will form a contact angle that is larger than one that is formed at the downstream face and that is substantially a right angle, and so that the retention force of meniscuses M formed at small holes 6b in the filter member 6 is reduced, enabling an air bubble B1 to more easily pass through the filter member 6.

FIG.3



EP 0 887 190 A2

Description

The present invention relates to an ink-jet recording device. More specifically it relates to an ink-jet recording device that comprises a recording head, for ejecting ink droplets through nozzle openings in response to print signals, and an ink cartridge for supplying ink to the recording head.

For the process by which pressure is applied to ink in a pressure generation chamber using pressurization means, such as a piezoelectric vibrator, and is ejected as ink droplets through nozzle openings of several tens of μm, a conventional ink-jet recording device has a filter that is inserted into a flow path connecting an ink cartridge to a recording head to prevent dust and large air bubbles from entering the pressure generation chamber, so that the clogging of the nozzle openings due to dust in the ink and the flow of air bubbles into the generation pressure chamber does not occur.

In Fig. 12(a) is shown an example recording head wherein a filter member is inserted into one part of a flow path. A filter chamber E is formed by cutting a shared area of an ink supply needle B, which serves as one part of a connection path with an ink cartridge A, and an ink flow path D, which communicates with a recording head C. A filter member F made of either an unwoven material or a mesh material is located at the filter chamber E, so that air bubbles that are generated or that become larger in the ink cartridge, or dust, are captured and can not enter the recording head C.

The tiny openings in the filter member are made smaller than the diameter of the nozzle opening in order to facilitate the capture of air bubbles, and the flow rate for ink is reduced by increasing the cross sectional area of the filter chamber E so as to prevent an increase in a flow path resistance due to the insertion of the filter material. Therefore, air bubbles that increase in size compared with the size of the mesh are stopped by a meniscus formed on the filter member F even during an ink refill operation or a recovery operation, at which time the ink flow rate at the filter member F is comparatively high. As a result, not only air bubbles can not be fully discharged from the filter F, but also the air bubbles accumulate on the surface of the filter F and interrupt the flow of ink, and the printing performance is drastically deteriorated.

It is the object of the present invention to overcome the drawbacks and disadvantages of the prior art. This object is solved by the ink-jet recording device according to independent claims 1 and 8.

Further advantageous features, aspects and details of the invention are evident from the dependent claims, description, examples and figures. The claims are to be understood as a first non-limiting approach of defining the invention in general terms.

In one aspect, the present invention seeks to provide an inkjet recording device that can eliminate the accumulation of air bubbles at a filter member, and that can supply an adequate volume of ink to a recording head for printing.

According to an aspect of the present invention, an ink-jet recording device comprises:

a recording head for receiving ink fed along a first ink supply path and for ejecting ink droplets;
a second ink supply path along which ink from an ink cartridge is fed to the first ink supply path; and
a filter member interposed in a shared area between the first ink supply path and the second ink supply path,

wherein an ink lyophilic property is provided for the filter member so that air bubbles that contact the filter material form a contact angle at substantially a right angle.

Since air bubbles on the surface of a filter member form contact angles that are substantially right angles, meniscuses that are formed at the filter member are weak, so that air bubbles can easily pass through the filter member and proceed downstream. The above mentioned and other features and aspects of the present invention are illustrated by the following drawings, in which

Fig. 1 is a cross-sectional view of a filter member of an ink-jet recording head according to an embodiment of the present invention.
Fig. 2 is an enlarged cross-sectional view of the filter member according to the embodiment of Fig. 1.
Fig. 3 is a diagram illustrating the movement of air bubbles captured at the filter member.
Fig. 4 is an enlarged cross-sectional view of another example filter member of the present invention.
Figs. 5(I) to (III) are diagrams showing the procedures for fabricating the filter member.
Fig. 6 is a diagram illustrating the movement of air bubbles captured at the filter member.
Fig. 7 is a diagram showing an additional example filter member of the present invention.
Figs. 8(I) to (III) are diagrams illustrating the movement of air bubbles captured at the filter member.
Fig. 9 is a cross-sectional view of another embodiment of the present invention.
Fig. 10(a) and (b) are diagrams illustrating the movements of air bubbles captured at the filter member.
Fig. 11 is a cross-sectional view of an additional embodiment of the present invention.
Fig. 12(a) is a diagram showing a system for supplying ink to an ink-jet recording head, and Fig. 12(b) is a diagram illustrating the movement of an air bubble captured at a conventional filter member.

In Fig. 1 is shown the structure in the vicinity of a filter according to an embodiment of the present inven-

tion. An ink supply needle 3 is embedded in a base 4 upstream of a first ink supply path 1 that communicates with a recording head C (Fig. 12(a)). The ink supply needle 3 communicates with an ink cartridge A and forms a second ink supply path 2. A hollow portion formed in an area shared by the ink supply paths 1 and 2 forms filter chambers 5a and 5b, and a filter member 6 is positioned perpendicular to the direction in which ink flows. The ink lyophilic process is performed for the internal face of the upstream filter chamber 5b.

For the filter member 6, a base 6a is formed of cloth produced by twill-weaving metal or synthetic resin fiber or unwoven cloth produced by annealing metal fiber, and of a metal foil plate in which tiny through holes are formed by etching or one in which small holes are formed by electroforming. In addition, the exposed face in which are small holes 6b is irradiated with an electron beam to form ink lyophilic layers 6c with which air bubbles in the ink will form contact angles θ of from 70 to 90 degrees.

In this embodiment, when the ink supply needle 3 is inserted into the ink cartridge, and the recording head is sealed by a cap member so as to subject the ink supply paths 2 and 1 to a negative pressure, ink in the ink cartridge flows to the recording head. In this process, since as is shown in Fig. 3, air bubbles B located upstream of the filter member 6 contact the filter member 6 and form angles θ of from 70 to 90 degrees, the retention force of the meniscuses M, which are formed in the small holes 6b when the air bubbles B are attached, is weak, and the air bubbles B can therefore pass through the small individual holes 6b in the filter member 5.

When ink having a viscosity of $(3 \times 10)^{-3}$ Pa • s is passed at 0.3 grams/s through a filter member having a mesh diameter of 20 μm and an area of 50 mm^2, a pressure difference of 200 to 300 Pa is produced. The pressure required for air bubbles to be passed through a filter member having a mesh diameter of 20 μm is represented as approximately 600 N x $\cos\theta$ when the angle formed when the air bubbles contact the filter member is denoted by θ.

Therefore, when the surface of the filter member is so processed that the angle θ formed when an air bubble contacts the filter member is from 70 to 90 degrees, the pressure required to pass an air bubble through the filter member is reduced to a value between 600N x 0.342 and 0. As a result, air bubbles can be discharged externally via the recording head.

For a filter for which the above process is not performed, since the contact angles θ' that are formed are smaller than 70 degrees, as is shown in Fig. 12(b), the retention force of the meniscuses M' that are formed by the air bubbles is greater than the pressure difference between the upstream and the downstream region of the filter member, and therefore, it is extremely difficult for air bubbles B' to pass through the small holes.

Fig. 4 is a diagram illustrating another example of the filter member. In this example, an ink repellent layer 10c is formed on the upstream faces of bases 10a of the filter member, and on the internal faces of small holes 10b, and an ink lyophilic layer 10d is formed on the downstream faces.

This filter can be easily fabricated as follows. An ink lyophilic layer 12 as described above is formed on the downstream faces of bases 11, and is sealed with a film, such as a dry film 13, that can easily be peeled off but that closely adheres to the layer 12 (Fig. 5(I)). Then, an ink repellent layer 14 is formed by employing a fluorine-containing silicon coupling process described in Japanese Unexamined Patent publication No. Sho 56-89569, or by employing a method described in Japanese Unexamined Patent Publication No. Sho 57-157765 for applying fluorocarbon via an adhesive layer, or by employing a process described in Japanese Unexamined Patent Publication No. Sho 60-183161 for forming a fluorocarbon resin layer by eutectoid plating or plasma polymerization, or by employing vapor deposition of a titanate coupling agent as described in Japanese Unexamined Patent Publication No. Hei 7-205428 (Fig. 5(II)). Finally, the dry film 13 is removed (Fig. 5(III)).

According to this embodiment, an air bubble B2 that reaches the upstream face of the filter member is impelled by the flow of ink, and passes through the small holes 10b of the filter member and reaches the downstream face (Fig. 6). Since the ink lyophilic layer is formed on the downstream face, the contact angle θ of an air bubble B3 on this face is 70 to 90 degrees, so that it is easily removed, flows further downstream, and is discharged to the exterior via the recording head.

In Fig. 7 is shown another embodiment of the present invention. An ink repellent layer 15a is formed only on the upstream center area of a filter member 15, and an ink lyophilic layer 15b is formed across the entire downstream face and on the upstream circumferential area.

In this embodiment, when ink is sucked in and passes through filter chambers 5a and 5b at a high flow rate, an air bubble B4 that has become enlarged (Fig. 8(I)) is passed through the ink repellent layer 15a and a small air bubble B5 is formed downstream (Fig. 8(II)). When an air bubble B6 is passed through the filter member 15 and its size is decreased, it is rejected by the ink lyophilic layer downstream, and is carried along the ink flow path and discharged via the recording head (Fig. 8(III)).

In Fig. 9 is shown an additional embodiment of the present invention. In this embodiment, a filter member 21 is located substantially perpendicular to filter chambers 20a and 20b, and an ink inlet 22 is positioned higher than an outlet 23, so that the ink flows obliquely, high to low. For the filter member 21, an ink repellent layer 21a is formed on its upper face area, while an ink lyophilic layer 21b is formed on its lower face area.

According to this embodiment, when there is a low ink flow rate, as during printing, air bubbles B7 are captured at the ink lyophilic layer 21a on the upper face

area of the filter member 21, and can not pass through the filter 21.

When the recording head is subjected to a negative pressure to draw ink through the filter chambers 20a and 20b at a high flow rate, an air bubble B8 that has become enlarged is impelled downstream by dynamic pressure, passes through the ink repellent layer 21b formed in this area and into the recording head, and finally is discharged therefrom to the exterior.

In the above embodiment, an inlet is located horizontally. However, when as is shown in Fig. 11 an inlet 24 is located vertically in an upper area, the same effect can be obtained.

As is described above, according to the present invention, an ink-jet recording device includes a recording head for receiving ink fed along a first ink supply path and for ejecting ink droplets; a second ink supply path along which ink is fed from an ink cartridge to the first ink supply path; and a filter member interposed at a shared area between the first ink supply path and the second ink supply path, wherein an ink lyophilic property is provided for the filter member so that an air bubble that contacts the filter material forms a contact angle that is substantially a right angle. Therefore, since the retention force of meniscuses formed at the filter member is weak, air bubbles can be easily transferred to the downstream ink flow path.

Claims

1. An ink-jet recording device comprising:

   a recording head (C) for receiving ink fed along a first ink supply path (1) and ejecting ink droplets;

   a second ink supply path (2) along which ink is fed from an ink cartridge (a) to said first ink supply path (1); and

   a filter member (6; 15; 21) in a shared area interposed between said first ink supply path (1) and said second ink supply path (2),
   wherein an ink lyophilic property is provided for said filter member (6; 15; 21) so that an air bubble that contacts the filter material forms a contact angle that is substantially a right angle.

2. An ink-jet recording device according to claim 1, wherein said contact angle is 70 to 90 degrees.

3. An ink-jet recording device according to claim 1 or 2, wherein said ink lyophilic property is provided for the overall surface of said filter member (6; 15; 21).

4. An ink-jet recording device according to claim 1 or 2, wherein said ink lyophilic property is provided for the surface of said filter member (6; 15; 21) that is near said first ink supply path (1).

5. An ink-jet recording device according to claim 1 or 2, wherein said ink lyophilic property is provided for the surface of said filter member (6; 15; 21) that is near said second ink supply path (2).

6. An ink-jet recording device according to any of the preceding claims, wherein a hollow portion is formed in said shared area for said first ink supply path (1) and said second ink supply path (2).

7. An ink-jet recording device according to any of the preceding claims, wherein said filter member (6; 15; 21) is positioned substantially perpendicular to the path of an ink flow.

8. An ink-jet recording device comprising:

   a recording head (C) for receiving ink fed along a first ink supply path (1) and for ejecting ink droplets;

   a second ink supply path (2) along which ink from an ink cartridge (A) is fed to said first ink supply path (1); and

   a filter member (6; 15; 21) interposed in a joint area beteen said first ink supply path (1) and said second ink supply path (2),
   wherein an ink repellent layer (10c; 15a; 21a) is formed on at least one face of said filter member (6; 15; 21).

9. An ink-jet recording device according to claim 8, wherein said ink repellent layer (10c; 15a; 21a) is formed on the face of said filter member (6; 15; 21) close to said second ink supply path (2).

10. An ink-jet recording device according to claim 8 or 9, wherein an ink lyophilic property is provided for at least part of the face of said filter member (6; 15; 21) close to said second ink supply path (2) and/or for at least part of the face of said filter member (6; 15; 21) close to said first ink supply path (1).

11. An ink-jet recording device according to any of claims 8 to 10, wherein said filter member (6; 15; 21) is horizontally positioned and wherein said ink repellent layer (10c; 15a; 21a) is located in the center area.

12. An ink-jet recording device according to any of claims 8 to 10, wherein said filter member is vertically positioned and wherein said ink repellent layer (10c, 15a, 21c) is located in a lower area.

13. An ink-jet recording device according to any of

claims 8 to 12, wherein a hollow portion is formed in said shared area for said first ink supply path (1) and said second ink supply path (2).

14. An ink-jet recording device according to any of claims 8 to 13, wherein said filter member (6; 15; 21) is positioned substantially perpendicular to the path of an ink flow.

FIG.1

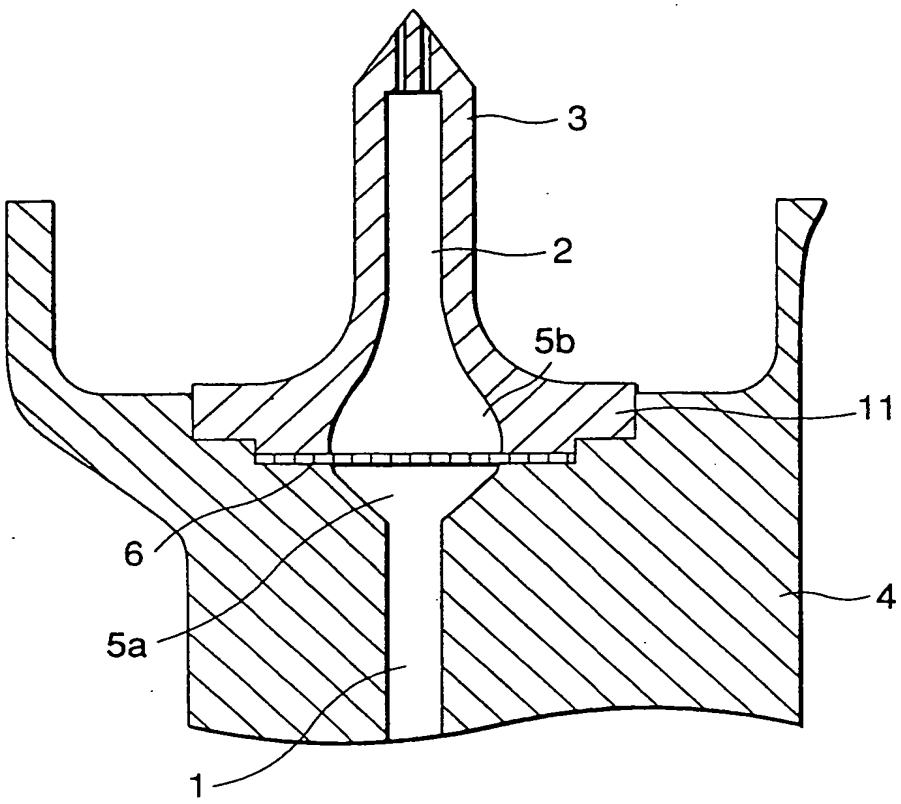


FIG.2

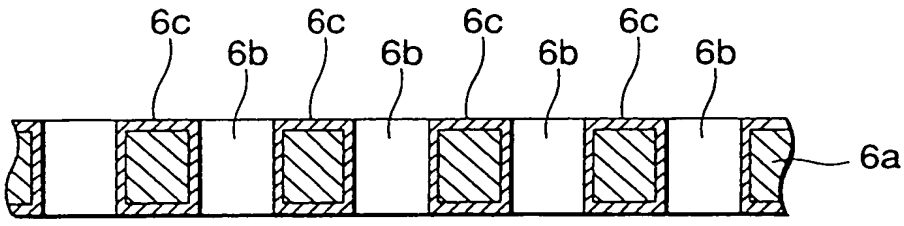


FIG.3

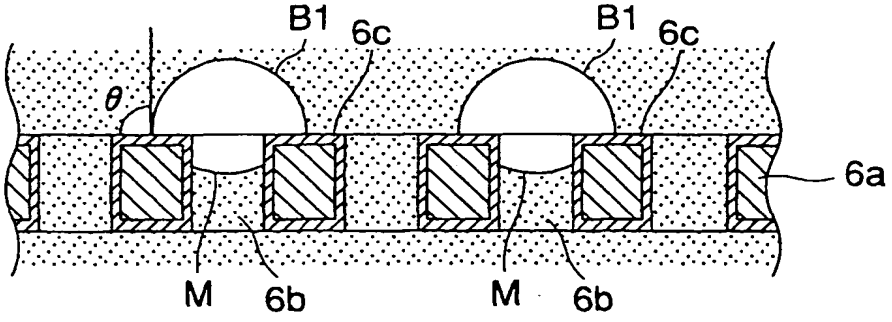


FIG.4

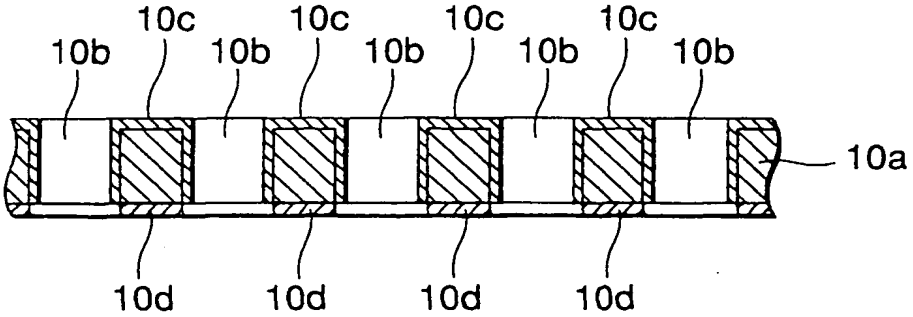


FIG.5 I

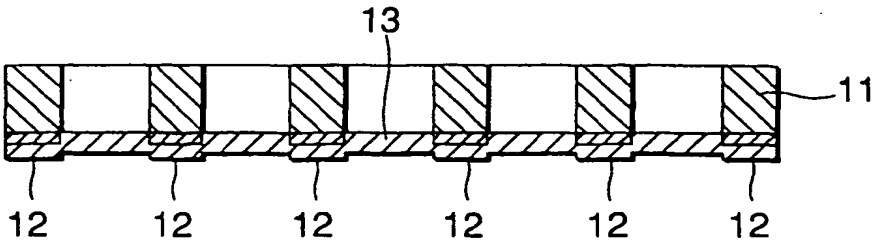


FIG.5 II

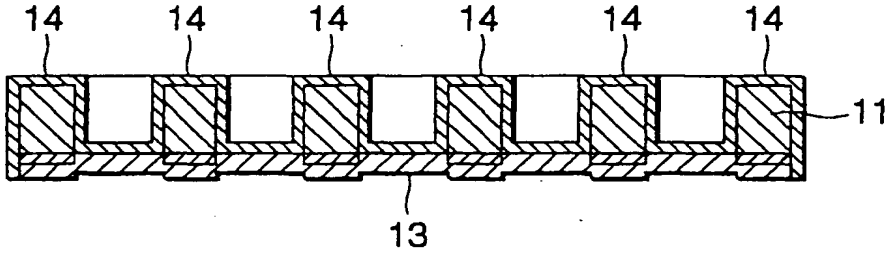


FIG.5 III

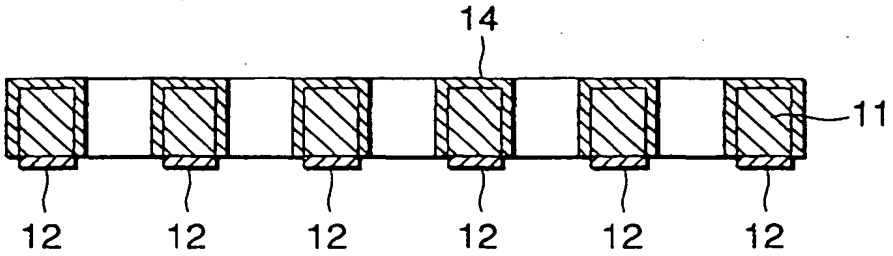


FIG.6

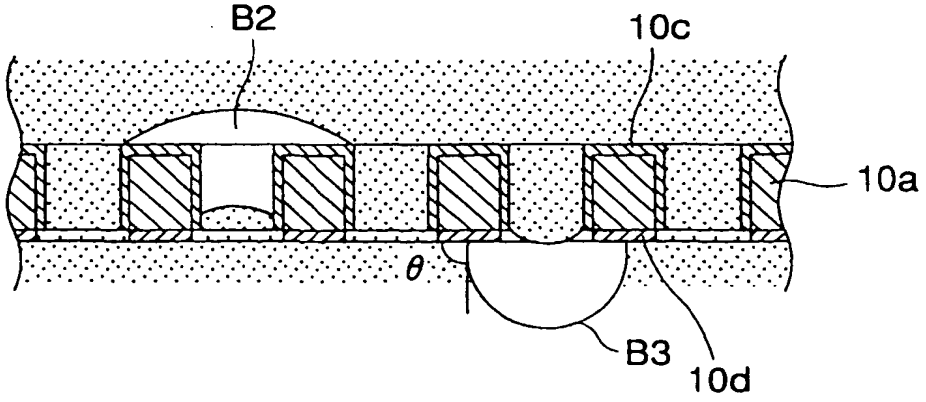


FIG.7

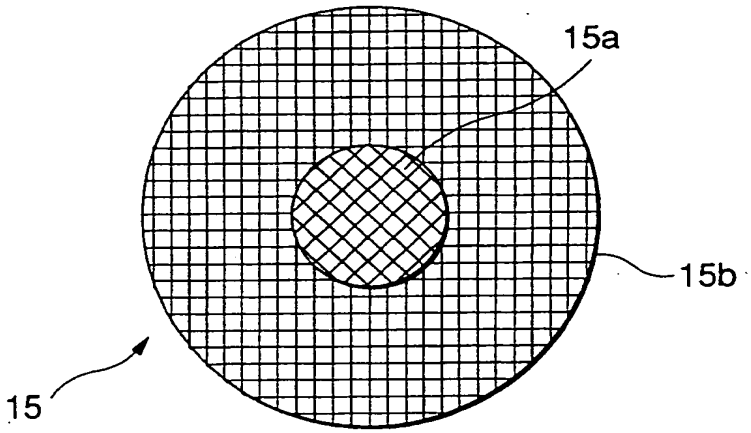


FIG.8 I

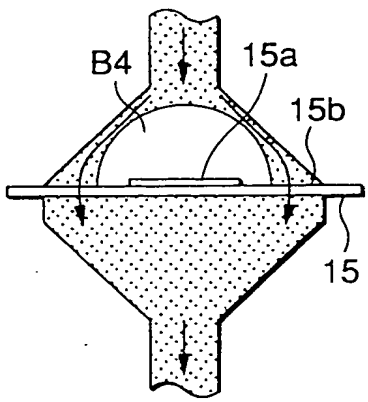


FIG.8 II

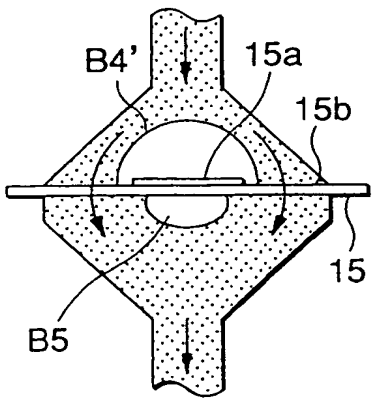


FIG.8 III

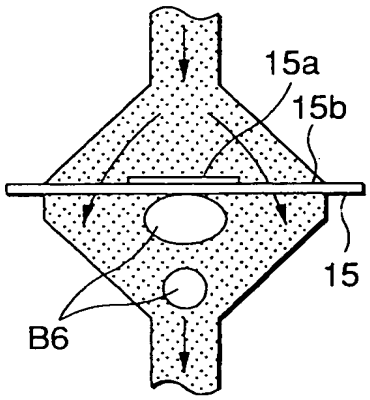


FIG.9

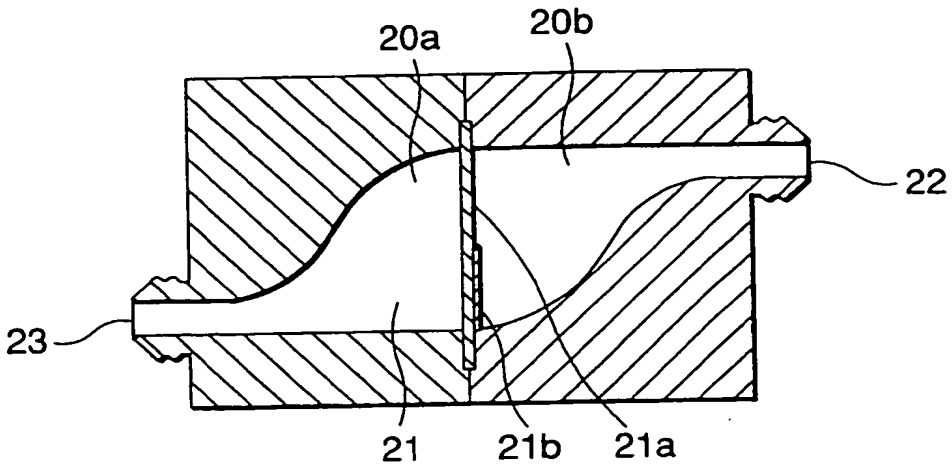


FIG.10(a)

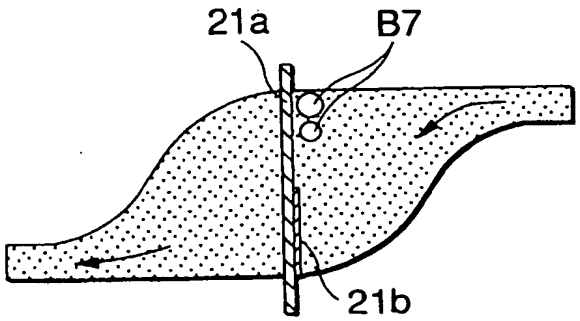


FIG.10(b)

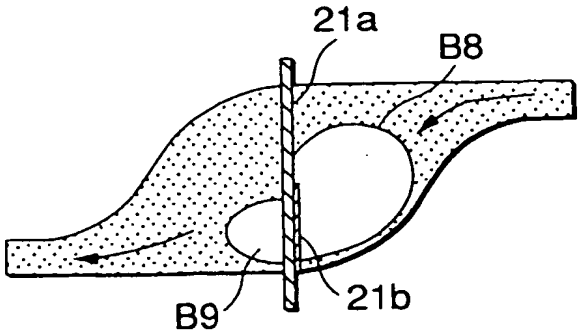


FIG.11

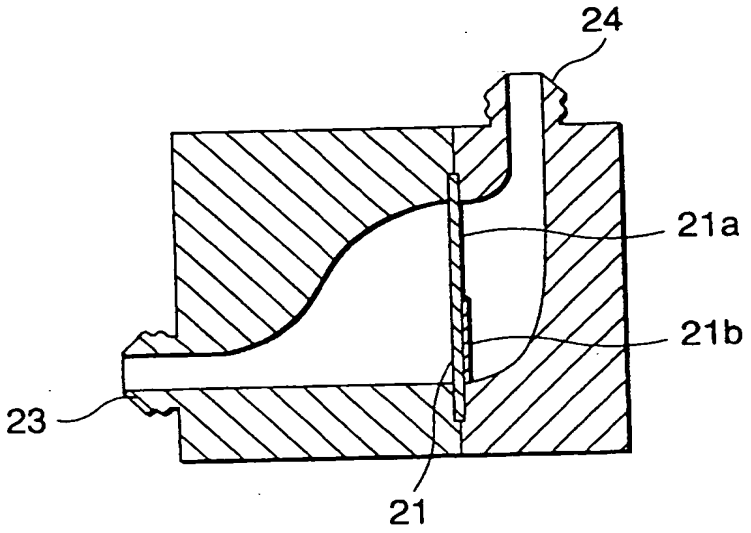


FIG.12(a)

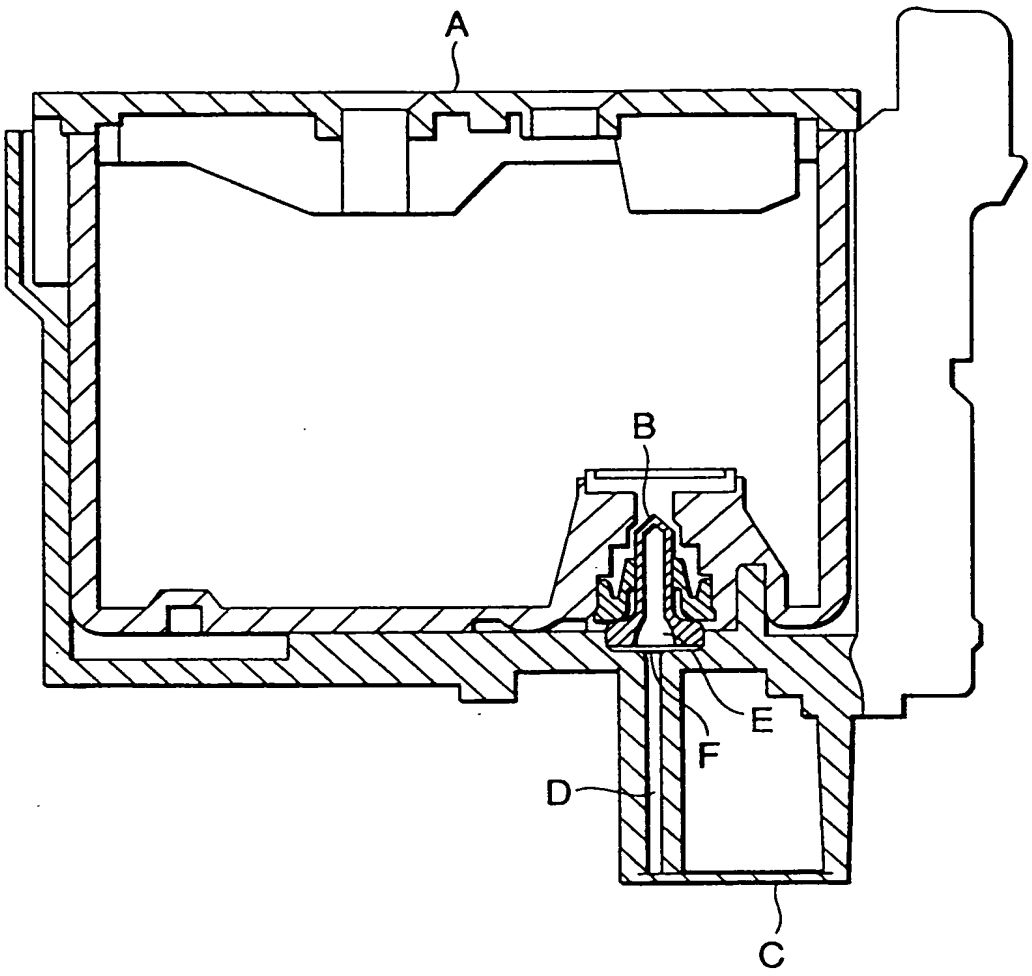


FIG.12(b)